Squark flavor constraints from $B \to K^* l^+ l^-$

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1.9.11, SUSY 2011, Fermilab

work in preparation with
Gudrun Hiller and Stefan Schacht

Outline

a) improved C_9-C_{10} constraints
   from $B \to K^* l^+ l^-$ -data [Bobeth, Hiller, van Dyk; '10,'11]

b) this work: implications for SUSY flavor

c) ... and (briefly) model-implications
   ➠ example: radiative flavor violation

ΔB=1 Effective Hamiltonian

$$\mathcal{H}_{eff} = -\frac{4G_F}{\sqrt{2}} V_{tb}V_{ts}^* \sum_i C_i(\mu) O_i(\mu) + \text{h.c.}$$

short distance physics

long distance physics

most important operators for $B \to K^* l^+ l^-$:

$$O_7 \sim m_b[\bar{s}_L \sigma_{\mu\nu} b_R] F^{\mu\nu} \qquad O_{9(10)} \sim [\bar{s}_L \gamma_\mu b_L][\bar{l}\gamma^\mu(\gamma_5) l]$$

$C_i = C_i^{SM} + C_i^{NP}$

- $|C_7|$: quite constrained by $b \to s\,\gamma$ data
- C_9, C_{10}: plenty of room for New Physics

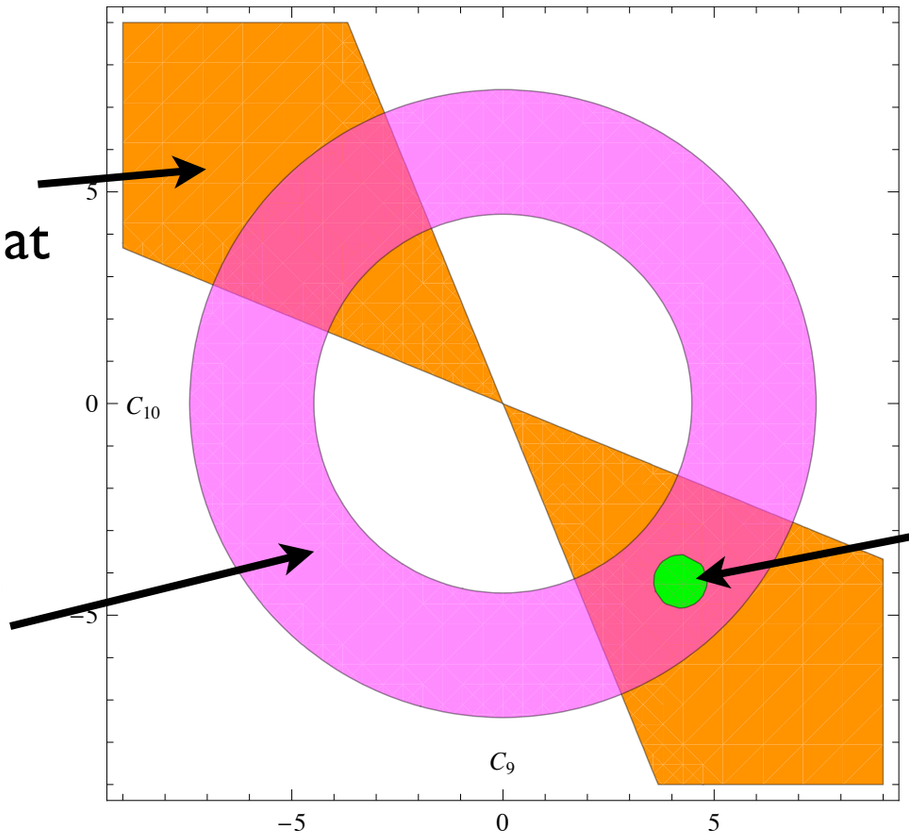
$B \to K^* l^+ l^-$ at low K* recoil ➠ new C_9-C_{10} constraints

toy plot:

[taken from 1106.1547]

from $A_{FB} \sim Re\{C_9^* C_{10}\}$ at low K* recoil

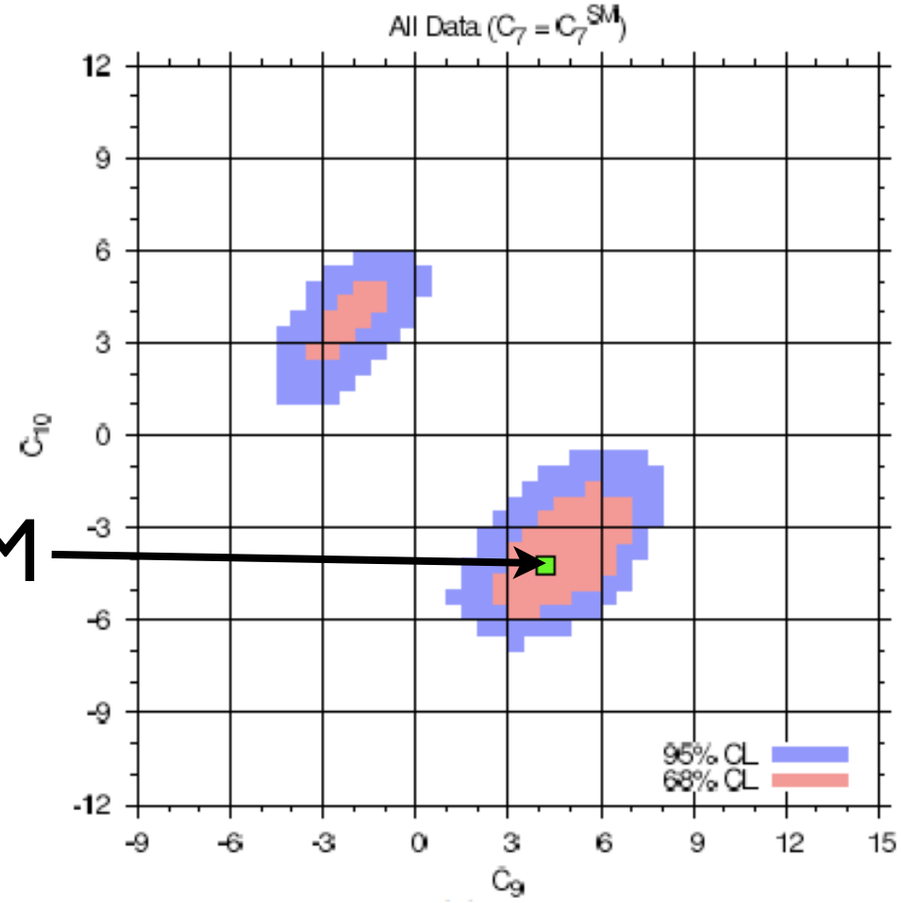
from $BR(B \to K^* l^+ l^-) \sim |C_9|^2 + |C_{10}|^2$



SM

actual analysis:

[Bobeth et. al., JHEP 1007:098,2010]



➠ what are consequences for BSM models?

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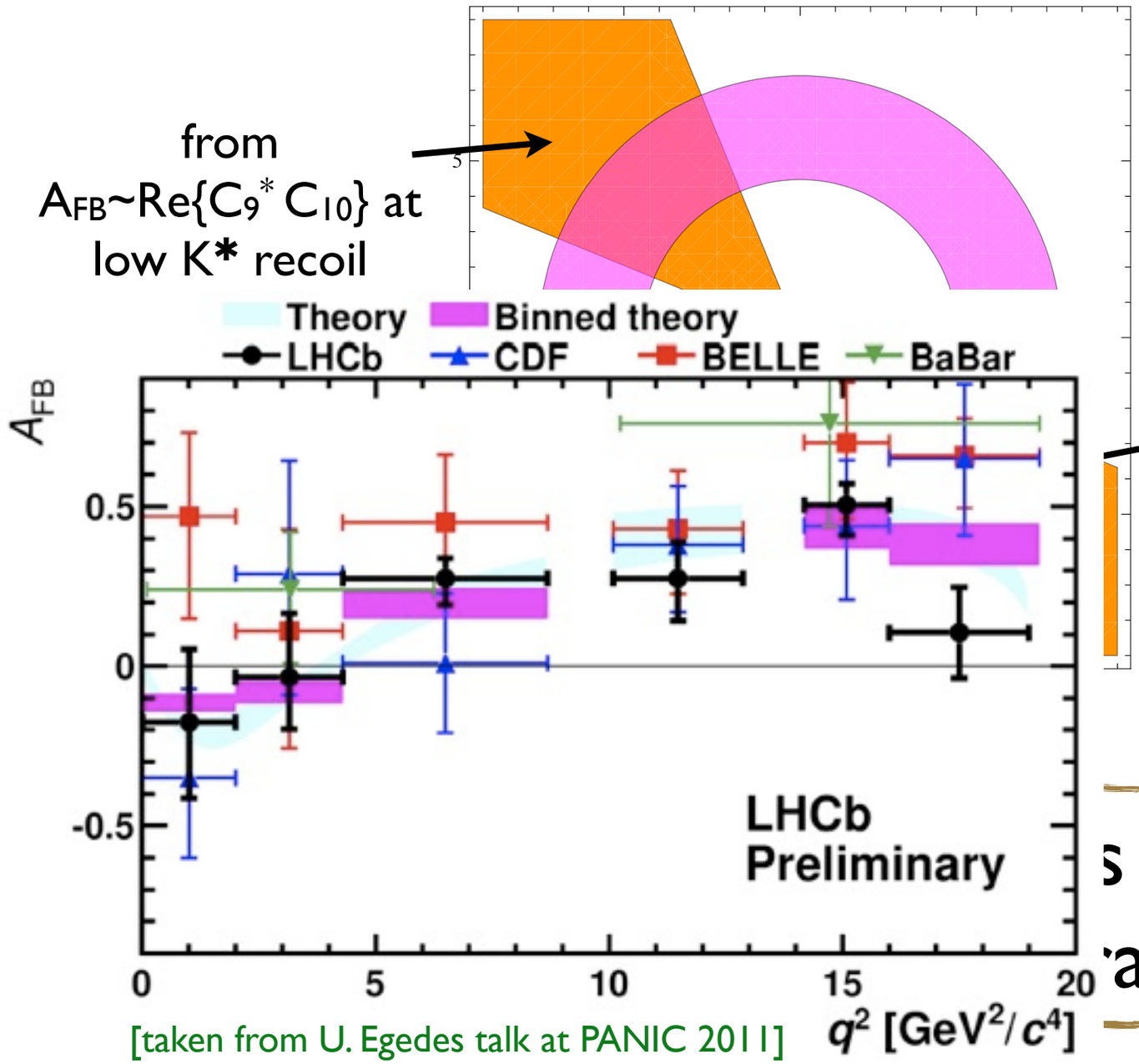

[taken from U. Egedes talk at PANIC 2011]

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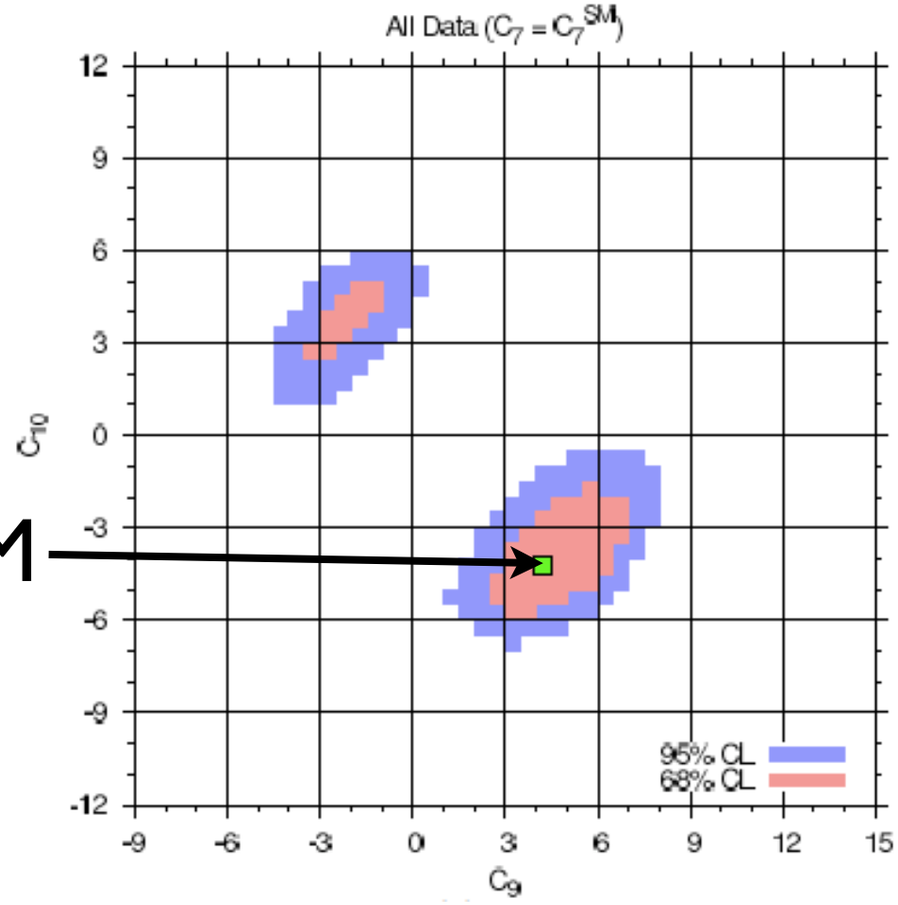

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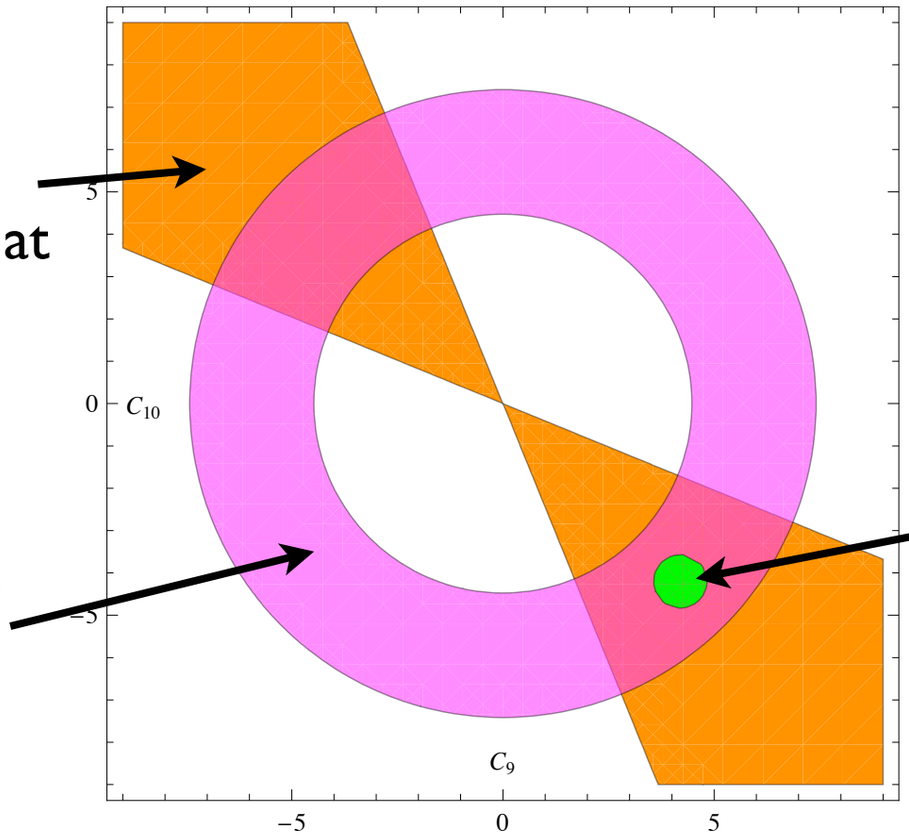

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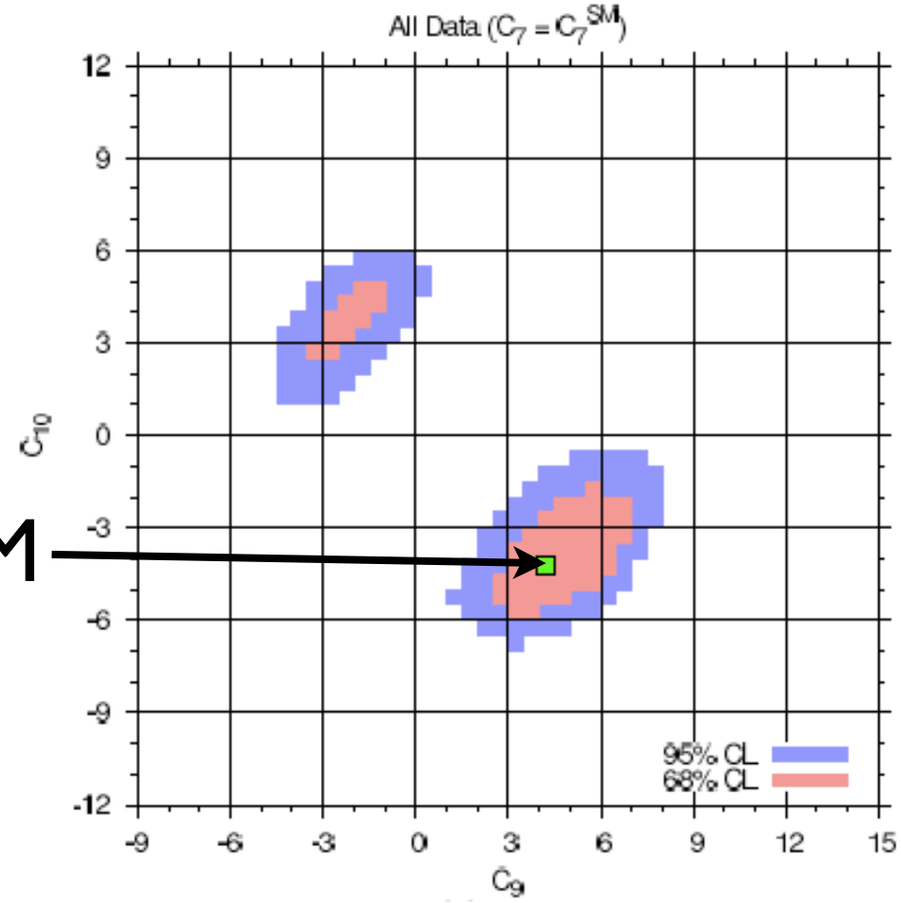

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Squark mass matrices in SCKM basis

$$M^2_{\tilde{u}} \equiv \begin{pmatrix} & & \tilde{u} & \tilde{c} & \tilde{t} & & \tilde{u} & \tilde{c} & \tilde{t} \\ & \tilde{u} & m^2_{\tilde{u}_L} & (\Delta^u_{12})_{LL} & (\Delta^u_{13})_{LL} & & (\Delta^u_{11})_{LR} & (\Delta^u_{12})_{LR} & (\Delta^u_{13})_{LR} \\ L & \tilde{c} & (\Delta^u_{12})^*_{LL} & m^2_{\tilde{c}_L} & (\Delta^u_{23})_{LL} & & (\Delta^u_{21})_{LR} & (\Delta^u_{22})_{LR} & (\Delta^u_{23})_{LR} \\ & \tilde{t} & (\Delta^u_{13})^*_{LL} & (\Delta^u_{23})^*_{LL} & m^2_{\tilde{t}_L} & & (\Delta^u_{31})_{LR} & (\Delta^u_{32})_{LR} & (\Delta^u_{33})_{LR} \\ & & --- & --- & --- & --- & --- & --- & --- \\ & \tilde{u} & & & & & m^2_{\tilde{u}_R} & (\Delta^u_{12})_{RR} & (\Delta^u_{13})_{RR} \\ R & \tilde{c} & & h.c. & & & (\Delta^u_{12})^*_{RR} & m^2_{\tilde{c}_R} & (\Delta^u_{23})_{RR} \\ & \tilde{t} & & & & & (\Delta^u_{13})^*_{RR} & (\Delta^u_{23})^*_{RR} & m^2_{\tilde{t}_R} \end{pmatrix}$$

symbolically

$$\sim \begin{pmatrix} \tilde{m}^2_Q & A_U \\ A_U & \tilde{m}^2_U \end{pmatrix}$$

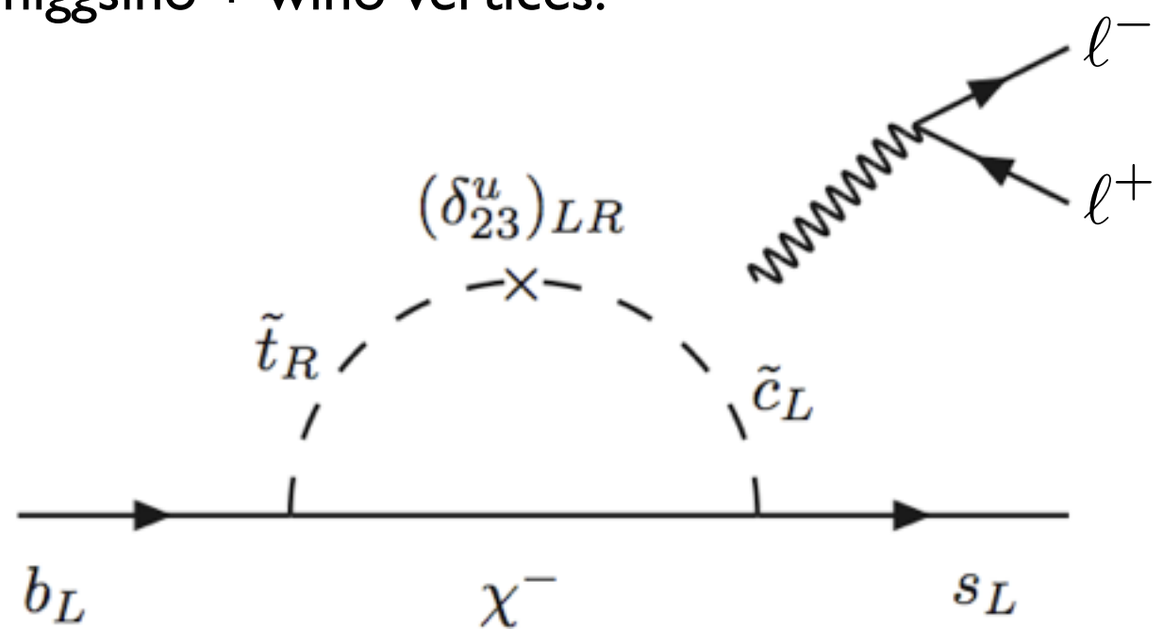
($M^2_{\tilde{d}}$: analogous...)

we try to constrain $(\Delta^u_{23})_{LR}$
more precisely: the
dimensionless parameter $(\delta^u_{23})_{LR} = \dfrac{(\Delta^u_{23})_{LR}}{\frac{1}{6}\left(5m^2_{\tilde{q}} + m^2_{\tilde{t}_R}\right)}$

other squark flavor parameters:
quite constraint by $b \to s\gamma$ and/or subleading in C_9, C_{10} !

$C_{9,10}^{NP}$ from squark-chargino loops

example: Z,γ-penguin with higgsino + wino vertices:



$$C_9^{\mathrm{MI},\tilde{\chi}} = \frac{K_{cs}^*}{K_{ts}^*}\frac{1}{4\,s_W^2}\frac{\lambda_t}{g_2}\left((4s_W^2-1)F^{\text{Z-p.}} + 4s_W^2\frac{m_W^2}{m_{\tilde{q}}^2}F^{\gamma\text{-p.}} - \frac{m_W^2}{m_{\tilde{q}}^2}F^{\text{box}}\right)(\delta^u_{23})_{LR}$$

$$C_{10}^{\mathrm{MI},\tilde{\chi}} = \frac{K_{cs}^*}{K_{ts}^*}\frac{1}{4\,s_W^2}\frac{\lambda_t}{g_2}\left(F^{\text{Z-p.}} + \frac{m_W^2}{m_{\tilde{q}}^2}F^{\text{box}}\right)(\delta^u_{23})_{LR}$$

[Cho et al.;'96 and Lunghi et al.;'99]

SUSY parameter scan

test each parameter point for

- b→sγ constraints
- ρ-parameter constraints
- Higgs-, chargino-, stop mass limits

	min.	max.	# of scanned points
$\tan\beta$	2	15	7
$m_{H^\pm}$	300	1000	7
M_2	100	1000	7
$\lvert\mu\rvert$	80	1000	7
$m_{\tilde{t}_R}$	200	600	7
A_t	−1000	1000	20

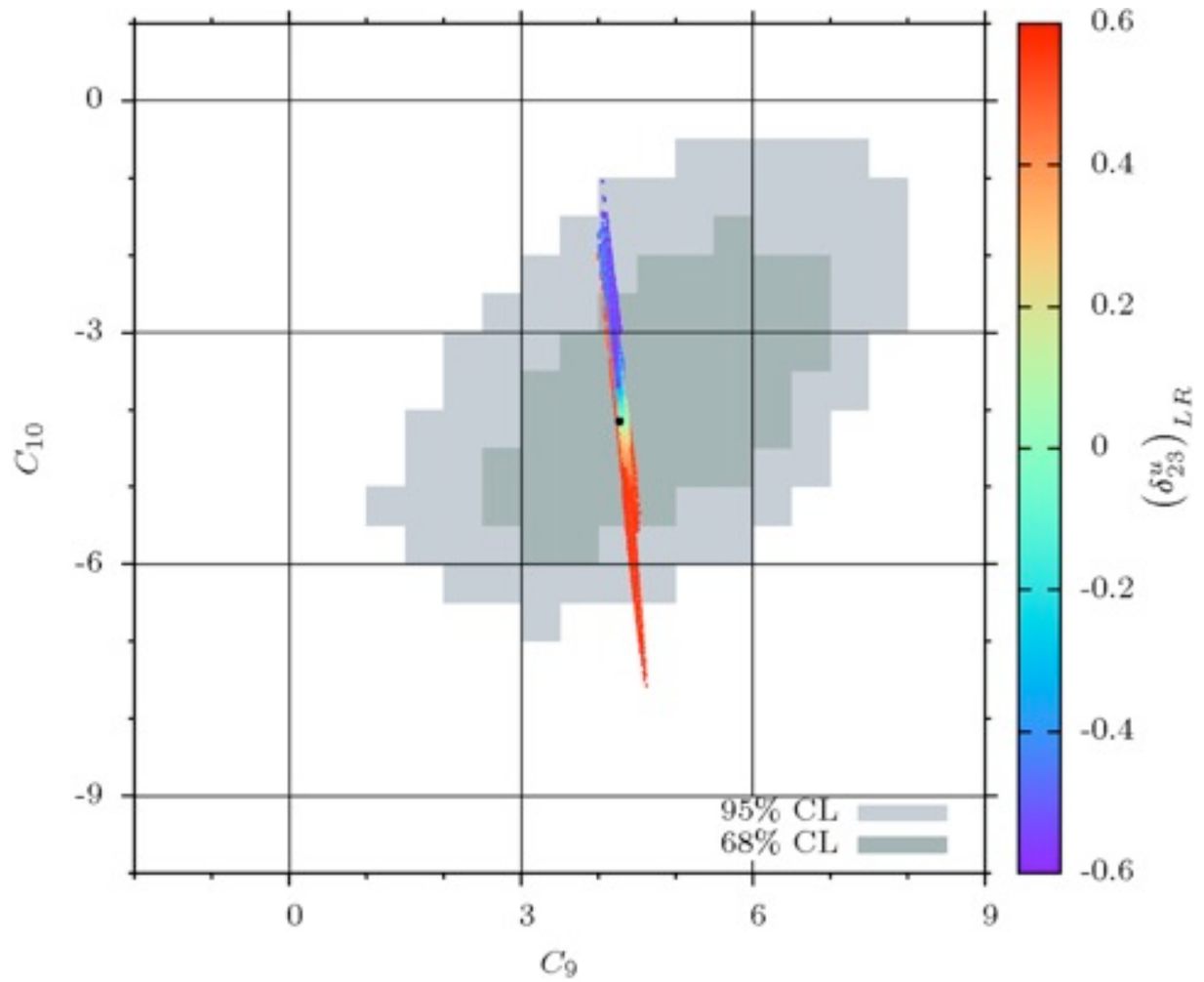
➠ maximal reach:

(1) for MFV-SUSY

- $|C_9^{NP}/C_9^{SM}|$ < 2%
- $|C_{10}^{NP}/C_{10}^{SM}|$< 8%

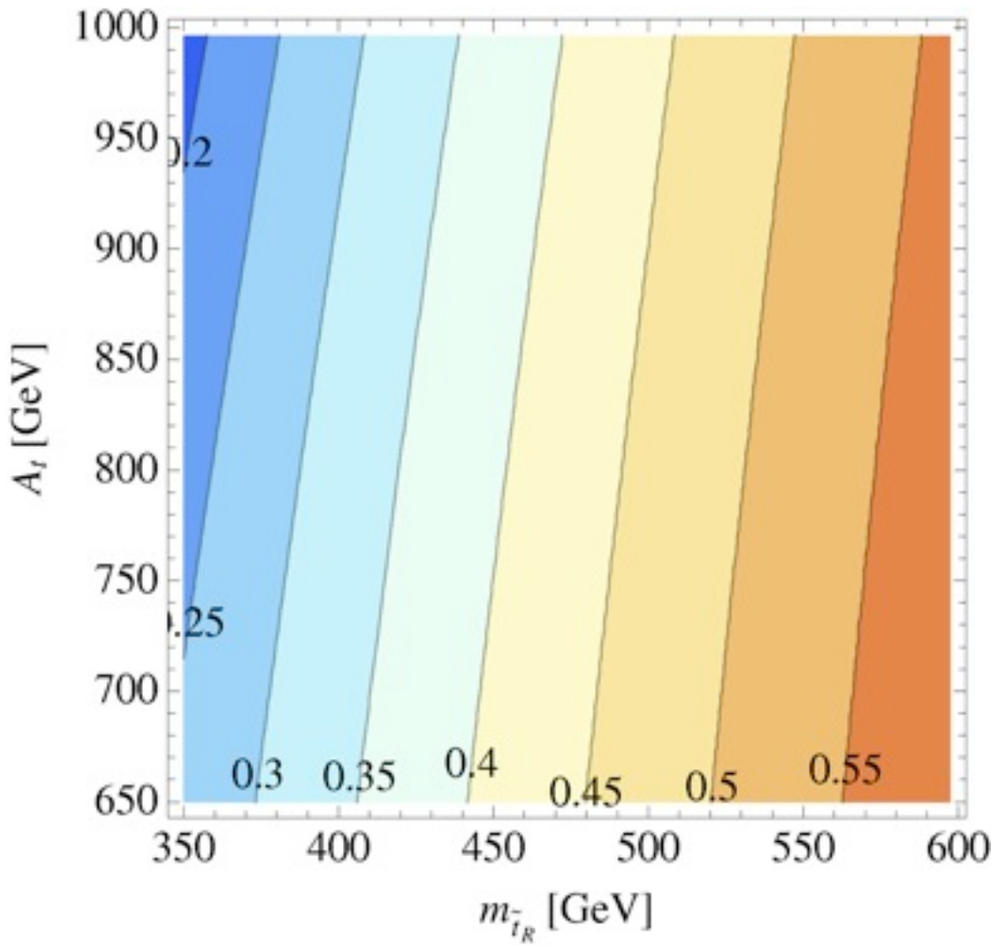
(2) for $(\delta^u_{23})_{LR} \neq 0$

- $|C_9^{NP}/C_9^{SM}|$ < 8%
- $|C_{10}^{NP}/C_{10}^{SM}|$< 82%

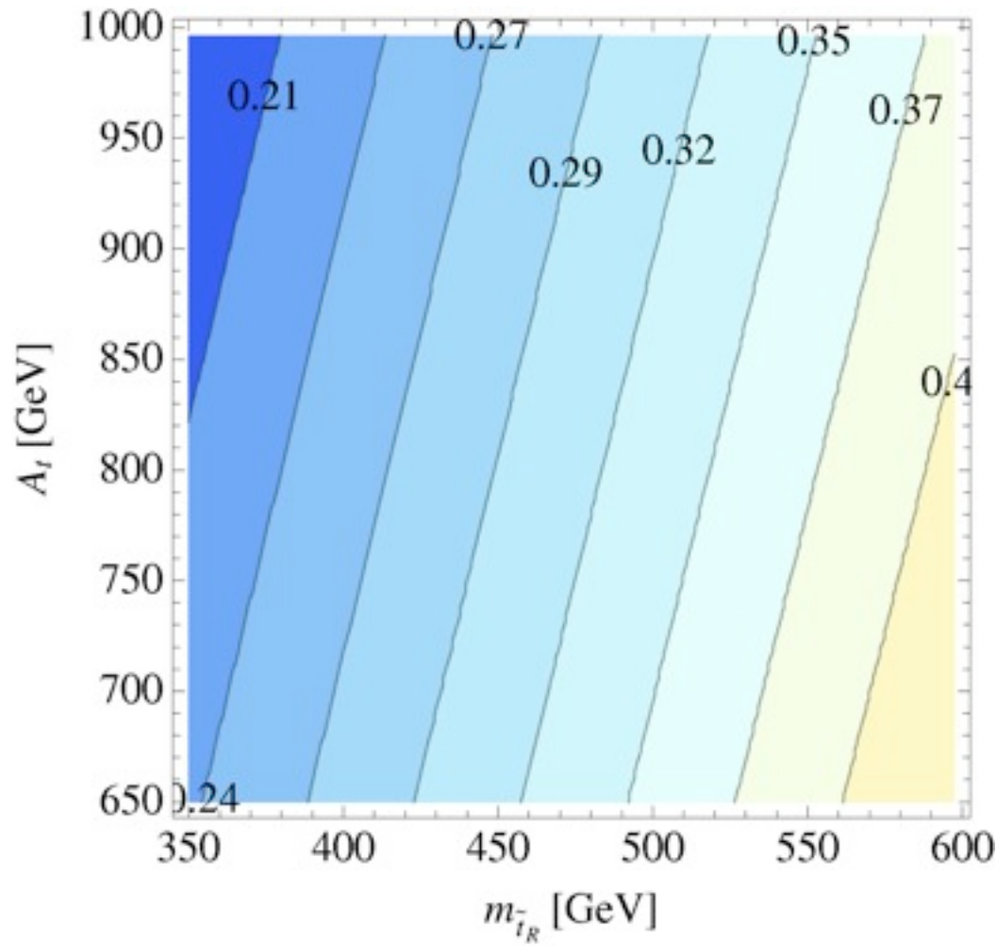


Improvement of $(\delta^u_{23})_{LR}$ -constraints

only b→sγ:



including B→K*l⁺l⁻:



other SUSY parameters:

$$m_{\tilde{\nu}} = 100\,\text{GeV},\ m_{H^\pm} = 400\,\text{GeV},\ m_{\tilde{g}} = 1\,\text{TeV},\ \tan\beta = 2,$$
$$M_2 = 100\,\text{GeV},\ \mu = -1\,\text{TeV},\ m_{\tilde{q}} = 1\,\text{TeV}$$

Implications for flavor-models ?

constraints still mild

➠ only models with large $(\delta^u_{23})_{LR} \sim A^u_{23}$ are affected

example: radiative flavor violation model of [Crivellin et al.;'11]

setup:

$(Y_q^{tree})_{ij} = \delta_{i,3}\delta_{j,3}\lambda_q \qquad V_{CKM}^{tree} = \mathbf{1}_3$

$\tilde{m}^2_Q, \tilde{m}^2_U, \tilde{m}^2_D$: diag, 1.+2. el. degenerate

flavor-breaking from A-terms only!

- quark mixing + masses generated from SUSY-loops with flavor-breaking A-terms
- to generate V_{cb} in up-sector need large A^u_{23}

Our results allow to constrain this model
...but work still in progress

Conclusions

- New theoretical and experimental results regarding $B \to K^* l^+ l^-$ yielded improved constraints on C_9/C_{10}
- We find that $(\delta^u_{23})_{LR}$ is the most sensitive SUSY flavor parameter
- Bounds are strengthened, but still only mild ... fortunately: good prospects from LHCb!
- can restrict models with large A^u_{23}